Kingscote (KI) [illegible]

AUSTRALIAN POST OFFICE

ETP 0363

TECHNICAL TRAINING PUBLICATION

Engineering Training Group, 6 Flinders Street, Melbourne, Victoria, 3000

SUBSCRIBERS EQUIPMENT COMPONENTS

PUBLISHED 1972

Page

1. INTRODUCTION

1.1 A telephone instrument is a combination of many individual components interconnected to allow the instrument to perform the following electrical functions:

- Indicate to the subscriber, by means of audible or visual signalling components, when another telephone service is calling.
- Apply an answering condition to stop the ringing condition after the appropriate answering procedure has been carried out.
- Convert speech energy to electrical energy for transmission to the distant telephone.
- Convert the received electrical speech energy to acoustical energy.
- Disconnect the call at the completion of the conversation.
- Generate electrical information from an information sending device, to establish a call to another telephone service.

1.2 This paper describes the functions, basic construction and principle of operation of the more common items of subscribers telephone equipment components.

How these components are interconnected to produce telephone circuits is explained in other Technical Training Publications.

2. TRANSMITTING AND RECEIVING COMPONENTS

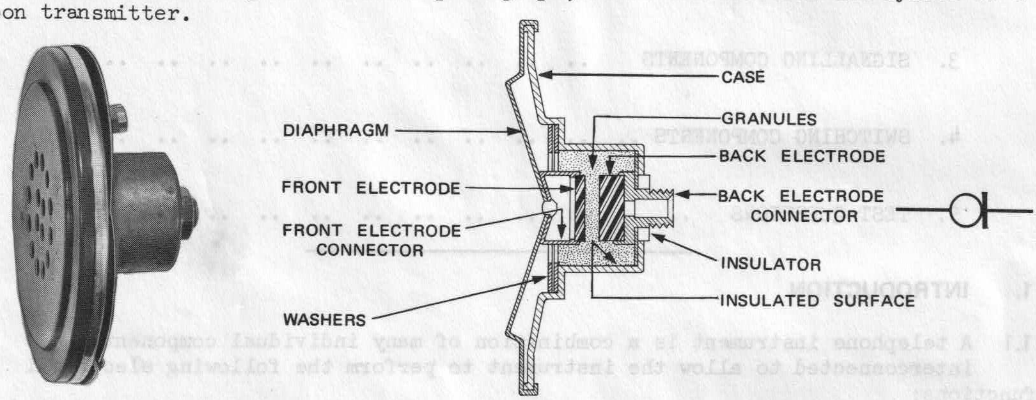
2.1 As stated in the Technical Training Publication "Sound Waves", there is only a small amount of acoustical energy available in speech. A component, called a transmitter, is used in each telephone to convert the acoustical energy of voice into another form of energy (electrical energy), which is capable of being transmitted over long distances.

Also, in each telephone there is a component called a receiver, which re-converts the transmitted electrical energy back into sound waves having similar characteristics to those which were impressed upon the transmitter in the distant telephone.

2.2 TRANSMITTER – CARBON TYPE.

FUNCTION. A carbon granule (abbreviated to carbon) telephone transmitter is a component which converts sound wave energy into mechanical energy, which in turn controls electrical energy connected to the transmitter.

BASIC CONSTRUCTION. Fig. 1 shows the photograph, basic construction and symbol of a carbon transmitter.



(a) Actual **Transmitter.** (b) Simplified Construction. (c) Symbol.

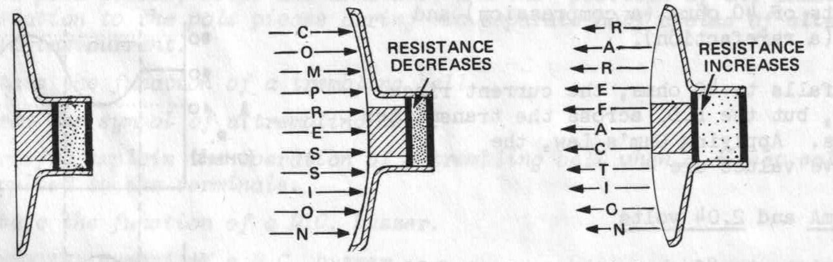
FIG. 1. CARBON TYPE TRANSMITTER.

This transmitter consists, basically, of many grains of carbon granules packed between two carbon electrodes mounted in a small chamber, which has insulated sides so as not to short-circuit the electrodes. The back electrode is fixed to the back of the chamber and the front electrodes is attached to the centre of a light, flexible diaphragm. The resistance of the transmitter is the resistance of the carbon granules between the front and back electrodes. Electrical connection is made to the back electrode via a hollow metal tube (back electrode connector) which is insulated from the case of the transmitter. Connection to the front electrode is via the transmitter case, the metallic diaphragm, and the metal cylinder (front electrode connector) attached between the diaphragm and the front electrode. To prevent the escape of carbon granules, a number of closely fitting silk and mica washers fit around the cylinder attached to the front electrode.

PRINCIPLE OF OPERATION. When a sound wave strikes the diaphragm, the varying pressures in the adjacent air particles cause it to vibrate. Acoustical energy is converted into mechanical energy in the vibration of the diaphragm.

A sound wave compression moves the diaphragm and front electrode inwards (Fig. 2b). The increased mechanical pressure "packs" the carbon granules closer together, and this increases the number of granules in contact with each other. Thus, the area of contact is increased and this reduces the contact resistance of the carbon between the electrodes.

Conversely, a rarefaction moves the diaphragm and front electrode outwards (Fig. 2c) and the transmitter resistance increases.

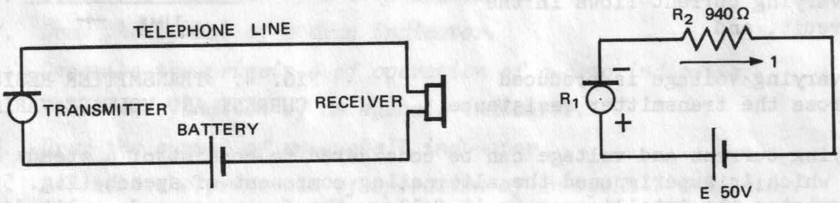


(a) Diaphragm Normal. (b) Diaphragm Moves Inwards. (c) Diaphragm Moves Outwards.

FIG. 2. OPERATION OF A CARBON TYPE TRANSMITTER.

When a battery is connected between the transmitter electrodes in an electric circuit, a D.C. flows through the conducting carbon granules. The variations in transmitter resistance vary or regulate the current in the circuit. Thus, a small value of acoustical energy can vary or control a comparatively large value of electrical energy supplied by a battery.

SIMPLE MATHEMATICAL ANALYSIS. A simple one-way telephone speaking circuit consists of a carbon transmitter, a receiver, and a telephone line connected in series with a battery (Fig. 3a).



(a) (b)

FIG. 3. BASIC ONE-WAY SPEAKING CIRCUIT.

Assume that the receiver resistance is 40 ohms, the line resistance is 900 ohms, and the resistance of the transmitter in the rest position is 60 ohms. The transmitter, therefore, has 940 ohms connected in series, as shown in Fig. 3b.

The circuit conditions when the transmitter is in the rest position are as follows:

Total circuit resistance (R_{TOTAL}) $= 60 + 940$

$= 1000$ ohms.

The circuit current $= \frac{E}{R_{TOTAL}}$

$= \frac{50}{1000} = \underline{50 \text{ mA}}.$

The PD across the transmitter (VI) $= I \times R$

$= \frac{50}{1000} \times 60 = \underline{3 \text{ volts}}.$

Assume, now, that a person speaks into the transmitter and the resistance varies between the limits of 40 ohms (a compression) and 80 ohms (a rarefaction).

When R1 falls to 40 ohms, the current rises slightly, but the P.D. across the transmitter decreases. Applying Ohm's Law, the respective values are -

51 mA and 2.04 volts

When R1 rises to 80 ohms, the current falls slightly, but the P.D. across the transmitter increases. The respective values are -

49 mA and 3.92 volts

These variations are shown graphically in Fig. 4.

Summarising, when a person speaks into the transmitter -

- the transmitter resistance varies,
- a varying current flows in the circuit, and
- a varying voltage is produced across the transmitter resistance.

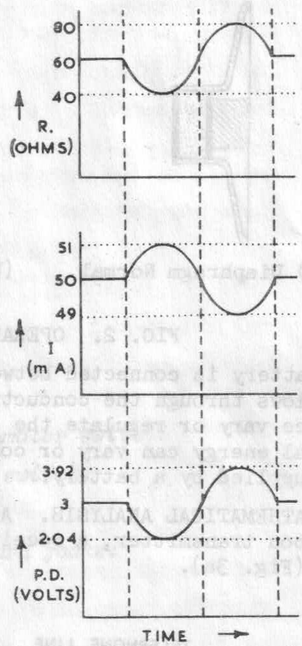


FIG. 4. TRANSMITTER RESISTANCE, CURRENT AND VOLTAGE VARIATIONS.

Both the varying current and voltage can be considered to consist of a steady direct component on which is superimposed the alternating component of speech (Fig. 5). The latter contains the intelligence as it follows the frequency and amplitude variations of the sound waves which vibrate the transmitter diaphragm; and it consists of fundamental and harmonic sine wave components, as in the original sound waves.

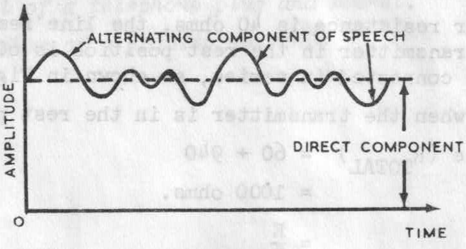


FIG. 5. A.C. AND D.C. COMPONENTS.

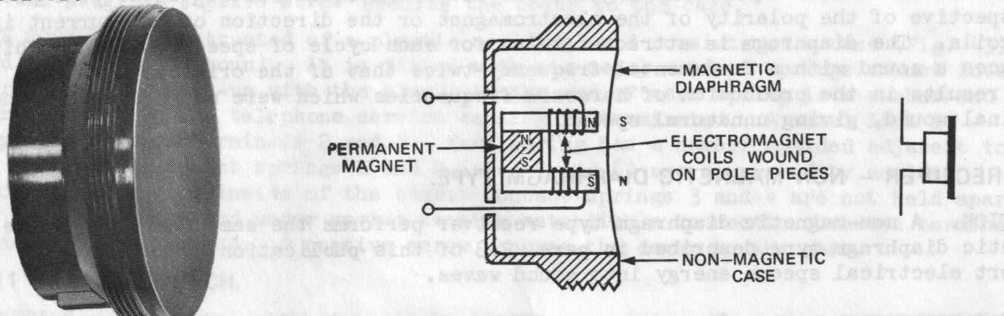
To simplify the understanding of telephone circuit operation, it is often convenient to assume that the carbon transmitter, during operation, develops a speech signal consisting of alternating voltages and currents at speech frequencies.

2.3 RECEIVER – MAGNETIC DIAPHRAGM TYPE.

FUNCTION. A receiver is a device which converts electrical speech energy into sound waves.

As the electrical speech signals received from a telephone line are extremely small (usually less than 0.1 μW), a telephone receiver must be efficiently designed to convert as much of the electrical energy as possible into acoustical energy. Also, speech signals consist of a wide range of frequencies which must be reproduced by the receiver so that the speech output will not sound distorted. A telephone receiver therefore must be designed for maximum sensitivity (or volume efficiency) as well as for good quality reception.

BASIC CONSTRUCTION. Fig. 6b shows the basic construction of a magnetic diaphragm receiver.

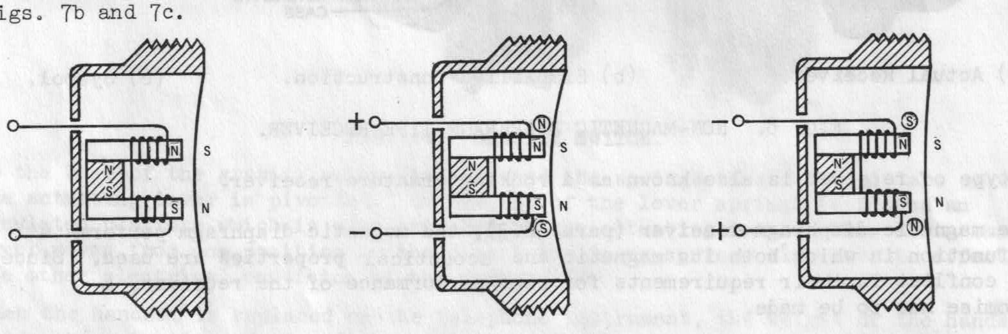


(a) Actual Receiver. (b) Simplified Construction. (c) Symbol.

FIG. 6. MAGNETIC DIAPHRAGM TYPE RECEIVER.

Electromagnet coils are wound on pole pieces attached to a permanent magnet. The end polarity of the pole pieces is the same as the magnet pole to which they are attached. A flexible magnetic diaphragm which is clamped around the circumference but free to move at its centre, is mounted a short distance from the pole pieces. By magnetic induction, opposite poles are produced in the diaphragm directly opposite the pole pieces and the diaphragm is normally stressed towards the pole pieces.

PRINCIPLE OF OPERATION. The coils are connected in series and produce opposite polarities at the pole tips. When the A.C. component of speech flows through the coils, the electromagnetism alternately aids and opposes the force exerted on the diaphragm by the permanent magnet, as indicated by the letters N and S in Figs. 7b and 7c.



(a) Diaphragm normal. (b) Diaphragm moves inwards. (c) Diaphragm moves outwards.

FIG. 7. OPERATION OF A MAGNETIC DIAPHRAGM TYPE RECEIVER.

The diaphragm moves from its normal stressed position, to positions closer to and further from the pole pieces, producing sounds having the same characteristics as the speech currents applied to the receiver. Thus electrical energy is converted into mechanical energy in the vibration of the diaphragm which, in turn, radiates acoustical energy.

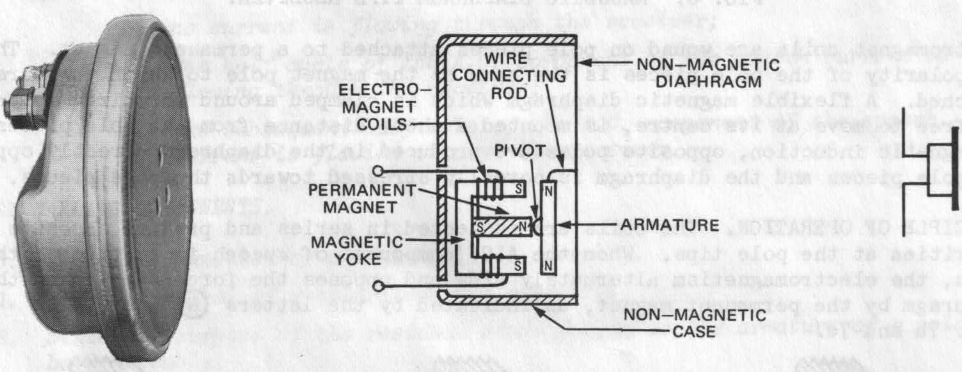
The permanent magnet enables the receiver to reproduce sounds with the same frequency as the speech currents applied to it. Each cycle of speech current causes the diaphragm to vibrate at the same frequency by merely increasing or decreasing the pull exerted on the diaphragm by the permanent magnet. The loudness of the sound produced by the receiver diaphragm for a given current input increases as the strength of the permanent magnet is increased. A receiver fitted with a permanent magnet is said to be polarised.

In a receiver without a permanent magnet, the diaphragm is attracted to the pole pieces irrespective of the polarity of the electromagnet or the direction of the current in the coils. The diaphragm is attracted twice for each cycle of speech current. This produces a sound with a fundamental frequency twice that of the original sound and also results in the production of harmonic frequencies which were not present in the original sound, giving unnatural speech.

2.4 RECEIVER – NON MAGNETIC DIAPHRAGM TYPE.

FUNCTION. A non-magnetic diaphragm type receiver performs the same function as the magnetic diaphragm type described in para. 2.3 of this publication, namely, to convert electrical speech energy into sound waves.

BASIC CONSTRUCTION. Fig. 8b shows the basic construction of a non-magnetic diaphragm receiver.



(a) Actual Receiver. (b) Simplified Construction. (c) Symbol.

FIG. 8. NON-MAGNETIC DIAPHRAGM TYPE RECEIVER.

This type of receiver is also known as a rocking armature receiver.

In the magnetic diaphragm receiver (para. 2.3), the magnetic diaphragm performs a dual function in which both its magnetic and acoustical properties are used. Since these conflict in their requirements for best performance of the receiver, a compromise has to be made.

In the rocking armature receiver (Fig. 8), these two functions are separate. The magnetic function is confined to the rocking armature, and the acoustical function to a light non-magnetic diaphragm, and each is designed for the best performance.

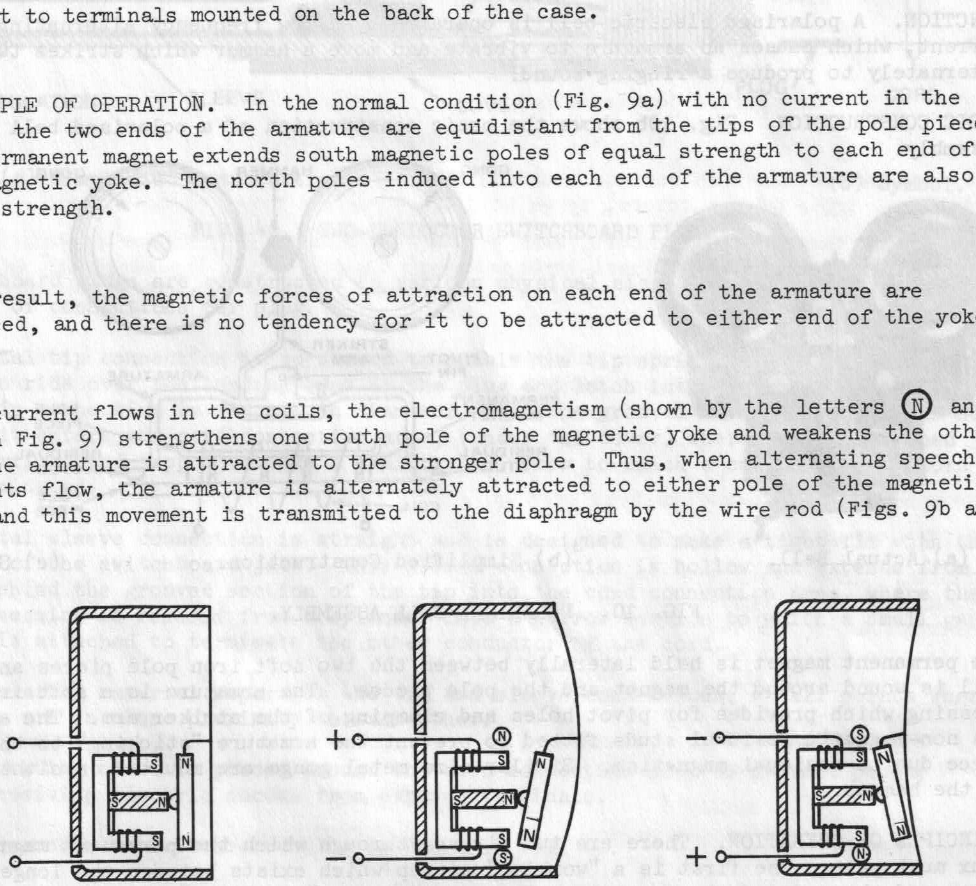
The permanent magnet is a small bar magnet, mounted centrally between the limbs of a U-shaped yoke which forms the two pole pieces. The armature rocks or pivots on the magnet, and is mechanically connected by a wire rod to a light flared non-magnetic alloy diaphragm.

The receiver is mounted in a sealed case. The ends of the electromagnet coils connect to terminals mounted on the back of the case.

PRINCIPLE OF OPERATION. In the normal condition (Fig. 9a) with no current in the coils, the two ends of the armature are equidistant from the tips of the pole pieces. The permanent magnet extends south magnetic poles of equal strength to each end of the magnetic yoke. The north poles induced into each end of the armature are also of equal strength.

As a result, the magnetic forces of attraction on each end of the armature are balanced, and there is no tendency for it to be attracted to either end of the yoke.

When current flows in the coils, the electromagnetism (shown by the letters N and S in Fig. 9) strengthens one south pole of the magnetic yoke and weakens the other; and the armature is attracted to the stronger pole. Thus, when alternating speech currents flow, the armature is alternately attracted to either pole of the magnetic yoke and this movement is transmitted to the diaphragm by the wire rod (Figs. 9b and 9c).



(a) Diaphragm normal. (b) Diaphragm moves outwards. (c) Diaphragm moves inwards.

FIG. 9. OPERATION OF ROCKING ARMATURE TYPE RECEIVER.

3. SIGNALLING COMPONENTS

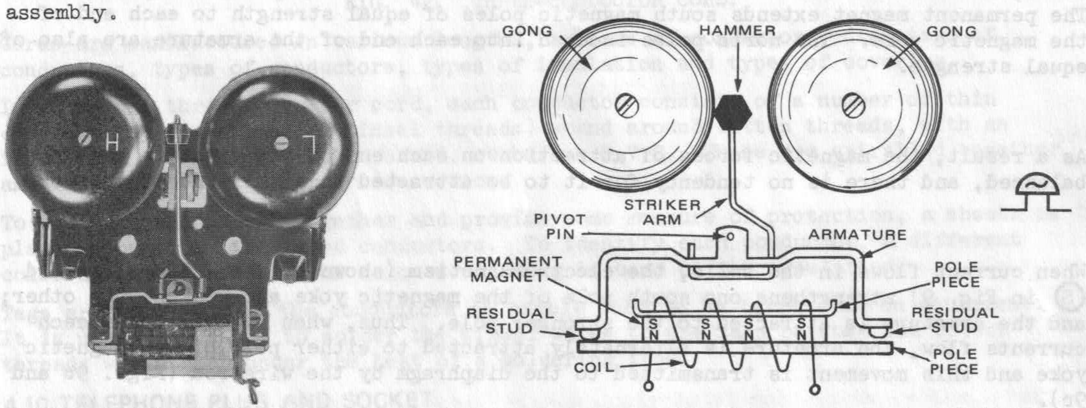
3.1 Signalling components are provided in all telephone systems to give an audible, or visual indication of the presence of an incoming telephone call. Their purpose is to gain the attention of the subscriber when another party has called their telephone number.

In addition to being able to indicate the presence of an incoming call to the subscriber, signalling components are also provided to originate outgoing calls from the telephone service.

3.2 BELL – POLARISED BELL ASSEMBLY.

FUNCTION. A polarised electric bell is operated by a low frequency alternating current, which causes an armature to vibrate and move a hammer which strikes two gongs alternately to produce a ringing sound.

BASIC CONSTRUCTION. Fig. 10b shows the basic construction of a polarised bell assembly.



(a) Actual Bell. (b) Simplified Construction. (c) Symbol.

FIG. 10. POLARISED BELL ASSEMBLY.

The permanent magnet is held laterally between the two soft iron pole pieces and the coil is wound around the magnet and the pole pieces. The armature is a soft iron pressing which provides for pivot holes and clamping of the striker arm. The armature has non-magnetic residual studs fitted to prevent the armature "sticking" to the pole piece due to residual magnetism. Similar size metal gongs are mounted on either side of the hammer.

PRINCIPLE OF OPERATION. There are two airgaps through which the permanent magnet flux must pass. The first is a "working" airgap which exists between the longer pole piece and the ends of the armature. The second is an "auxiliary" airgap which exists between the ends of the shorter pole piece and the sides of the armature (Fig. 11).

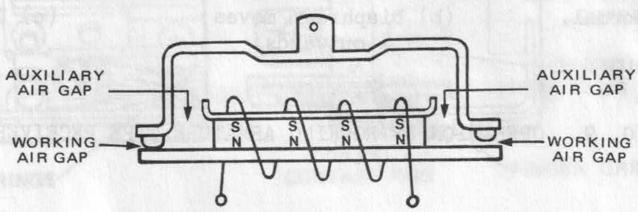


FIG. 11. MAGNETIC AIRGAPS.

The permanent magnet flux has two distinct and parallel paths, each of them passing through one auxiliary and one working airgap, as shown by the solid arrows in Fig. 12.

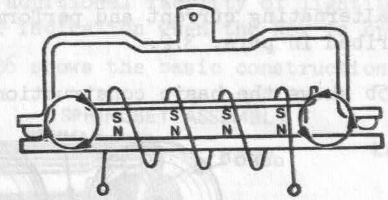


FIG. 12. MAGNETIC PATHS OF THE PERMANENT MAGNET.

When a low frequency A.C. ringing current is passed through the coil, a magnetic flux is produced around the coil and the polarities of the magnetic field are dependant on the direction of the current at particular instances of time.

One half cycle of alternating current, in the direction shown in Fig. 13, produces a magnetic flux in the longer pole piece, the armature and the two working airgaps as shown by the dashed arrows. The two magnetic fluxes at Y are in the same direction and aid each other, causing the armature to be attracted to the pole piece at Y. At Z the two fluxes oppose each other and the armature is not attracted at that end.

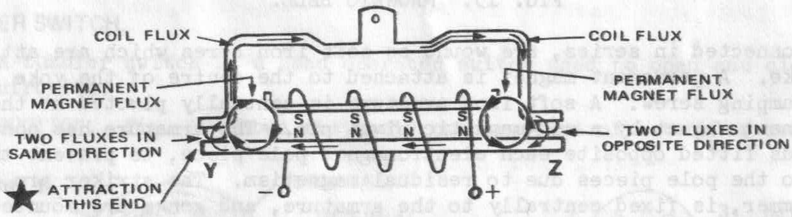


FIG. 13. MAGNETIC CIRCUITS WHEN CURRENT FLOWING IN COIL (1ST HALF CYCLE).

On the next half cycle, the permanent magnet flux is still in the same direction, but the coil flux has reversed (Fig. 14). In this case, the flux is weakened at Y and strengthened at Z and the armature is attracted to the pole piece at Z.

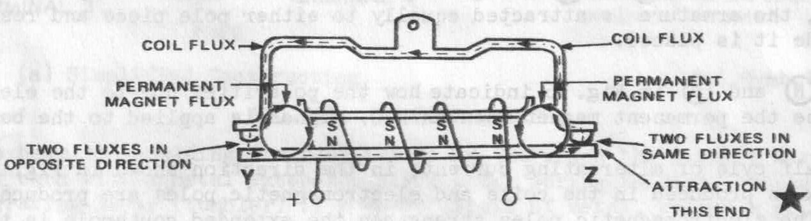


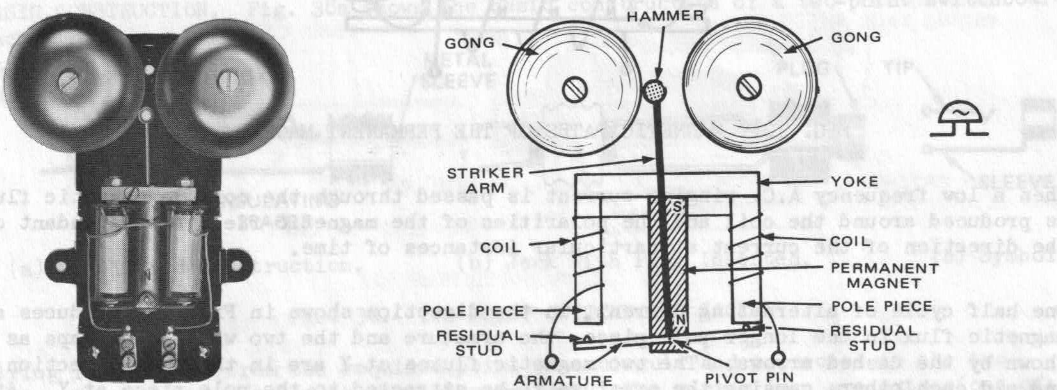
FIG. 14. MAGNETIC CIRCUITS WHEN CURRENT REVERSED IN COIL (2ND HALF CYCLE).

Thus the armature moves twice per cycle, and the attached hammer oscillates back and forth at the ringing current frequency to strike the gongs, which emit an audible sound.

3.3 BELL – MAGNETO.

FUNCTION. The magneto bell is an earlier type of polarised bell which is also operated by a low frequency alternating current and performs the same function as the polarised bell assembly described in para. 3.2.

BASIC CONSTRUCTION. Fig. 15b shows the basic construction of a magneto bell.



(a) Actual Bell. (b) Simplified Construction. (c) Symbol.

FIG. 15. MAGNETO BELL.

Two coils, connected in series, are wound on soft iron cores which are attached to a soft iron yoke. A permanent magnet is attached to the centre of the yoke and is held by a clamping screw. A soft iron armature is centrally pivoted at the other end of the permanent magnet by a non-magnetic pivot pin. The armature has non-magnetic residual studs fitted opposite each electromagnet pole piece, to prevent the armature "sticking" to the pole pieces due to residual magnetism. The striker arm, which carries a hammer, is fixed centrally to the armature, and gongs are mounted on either side of the hammer.

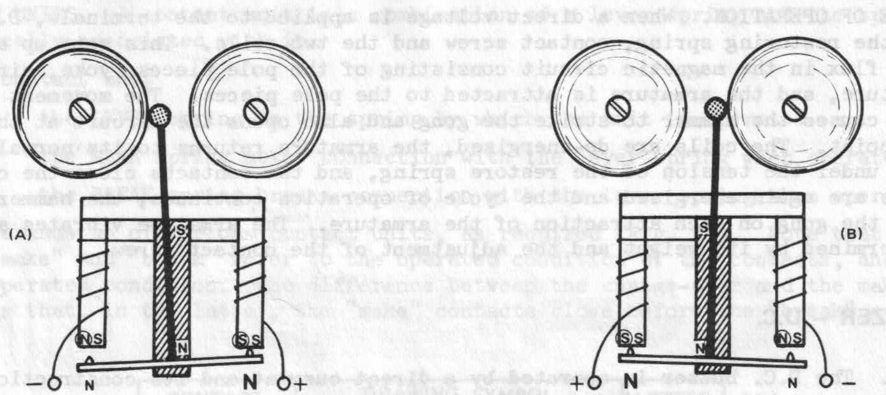
PRINCIPLE OF OPERATION. The flux from the permanent magnet divides between the two parallel paths of the magnetic circuit consisting of the magnet, yoke, electromagnet cores (pole-pieces), airgap and armature. The magnet extends south poles via the yoke to the ends of the pole pieces, and north poles to the ends of the armature, as indicated by the letters N and S in Fig. 16. In the normal condition, with no current in the coils, the armature is attracted equally to either pole piece and rests on whichever side it is placed.

The letters N and S in Fig. 16 indicate how the polarities due to the electromagnet aid and oppose the permanent magnet when an A.C. signal is applied to the bell.

During one half cyle of alternating current, in the direction shown in Fig. 16a, a magnetic flux is produced in the coils and electromagnetic poles are produced at the pole tips. The electromagnetic poles strengthen the extended southpole in the right hand pole-piece and weaken the other, causing the armature to be attracted to the stronger right hand pole.

During the next half cycle of alternating current, in the direction shown in Fig. 16b, the magnetic flux of the coils produces electromagnetic poles at the pole tips opposite to the previous half cycle. The electromagnetic poles strengthen the extended south pole in the left hand pole-piece and weaken the other, causing the armature to be attracted to the stronger left hand pole.

Thus, with alternating ringing currents, the armature is alternately attracted to each pole piece, and the hammer strikes each gong once per cycle.



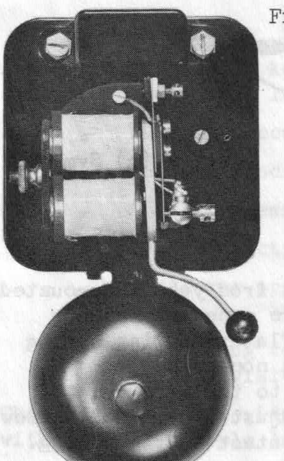
(a) 1st Half Cycle. (b) 2nd Half Cycle.

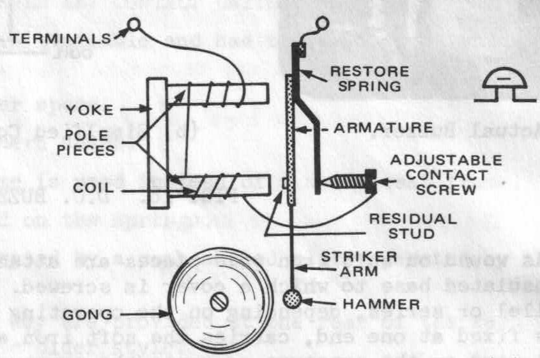
FIG. 16. OPERATION OF A MAGNETO BELL.

3.4 BELL – TREMBLING.

FUNCTION. The trembling bell is a non-polarised electric bell operated by a direct current. The bell has a self-interrupting armature with an attached hammer that strikes a gong to produce an audible sound.

Fig. 17b shows the basic construction of a trembling bell.





(b) Simplified Construction. (c) Symbol.

FIG. 17. TREMBLING BELL.

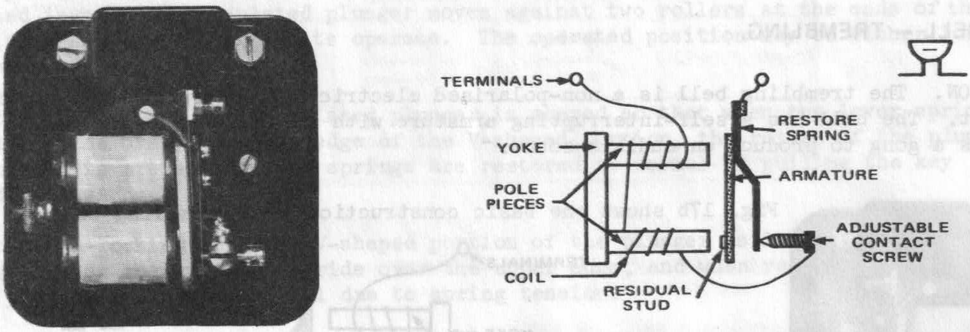
Two coils wound on soft iron pole-pieces are attached to a soft iron yoke and mounted on an insulated base. The coils are connected either in parallel or series, depending on the operating voltage (Fig. 17b shows a series connection). A flat restoring spring, which is fixed at one end, carries the soft iron armature. The non-magnetic residual stud on the armature prevents the armature "sticking" to the core due to residual magnetism. A pillar mounted on the base carries an adjustable contact screw and locking screw. The contact screw is adjusted to touch a contact on the spring. A reed and hammer are attached to the armature, and a gong is mounted close to the hammer.

PRINCIPLE OF OPERATION. When a direct voltage is applied to the terminals, D.C. flows through the restoring spring, contact screw and the two coils. This sets up a magnetic flux in the magnetic circuit consisting of the pole pieces, yoke, airgaps and armature, and the armature is attracted to the pole pieces. The movement of the armature causes the hammer to strike the gong and also opens the circuit at the contact point. The coils are de-energised, the armature returns to its normal position under the tension of the restore spring, and the contacts close the circuit. The coils are again energised and the cycle of operation continues, the hammer striking the gong on each attraction of the armature. The armature vibrates at a rate determined by its weight and the adjustment of the contact screw.

3.5 BUZZER – D.C.

FUNCTION. The D.C. buzzer is operated by a direct current and its construction is similar to a trembling bell (para. 3.4), but the gong, hammer and reed are omitted. The moving system is lighter and vibrates at a higher speed emitting a high-pitched note.

BASIC CONSTRUCTION. Fig. 18b shows the basic construction of a D.C. buzzer.



(a) Actual Buzzer. (b) Simplfied Construction. (c) Symbol.

FIG. 18. D.C. BUZZER.

Two coils wound on soft iron pole pieces are attached to a soft iron yoke and mounted on an insulated base to which a cover is screwed. The coils are connected either in parallel or series, depending on the operating voltage. A flat restoring spring which is fixed at one end, carries the soft iron armature. The non-magnetic residual stud on the armature prevents the armature "sticking" to the core due to residual magnetism. A pillar mounted on the base carries an adjustable contact screw and locking screw. The contact screw is adjusted to touch a contact on the spring.

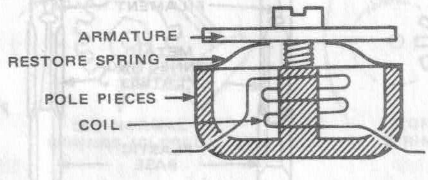
PRINCIPLE OF OPERATION. When a direct voltage is applied to the terminals, D.C. flows through the restoring spring, contact screw and the two coils. This sets up a magnetic flux in the magnetic circuit consisting of the pole pieces, yoke, airgaps and armature, and the armature is attracted to the pole pieces. The movement of the armature opens the circuit at the contact point. The coils are de-energised, the armature returns to its normal position under the tension of the spring, and the contacts close the circuit. The coils are again energised and the cycle of operation continues. The armature vibrates at a rate determined by its weight and the adjustment of the contact screw.

3.6 BUZZER – A.C. (COIL AND ARMATURE).

FUNCTION. The A.C. buzzer is operated by a low frequency alternating current and emits a buzzing sound.

BASIC CONSTRUCTION. Fig. 19b shows the basic construction of a coil and armature buzzer.

(a) **Actual Buzzer.**



(b) Simplfied Construction.

(c) Symbol.

FIG. 19. COIL AND ARMATURE TYPE A.C. BUZZER.

A coil is wound around the middle pole piece. The armature is held away from the body of the buzzer by a spring.

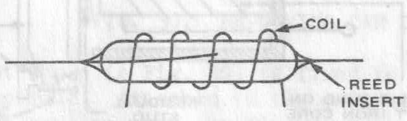
PRINCIPLE OF OPERATION. During the build up of one half cycle of the A.C. passing through the coil, a magnetic field is produced in the pole pieces and the armature. This causes the armature to be attracted to the pole pieces. When the current is reducing to zero on that half cycle, the magnetic field collapses and the armature is restored to the rest position under spring pressure. During the following half cycle, the armature is again attracted to the pole pieces as the current builds up to a maximum, and returns to the rest position when the current reduces to zero.

A buzzing noise is produced as a result of the metallic contact between the armature and the pole pieces.

3.7 BUZZER – A.C. (COIL AND REED INSERT).

FUNCTION. This component performs the same function as the A.C. buzzer described in para. 3.6.

BASIC CONSTRUCTION. Fig. 20a shows the basic construction of a coil and reed insert buzzer. The reed insert is placed inside a coil.



(a) Simplified Construction.

(b) Symbol.

FIG. 20. COIL AND REED INSERT TYPE A.C. BUZZER.

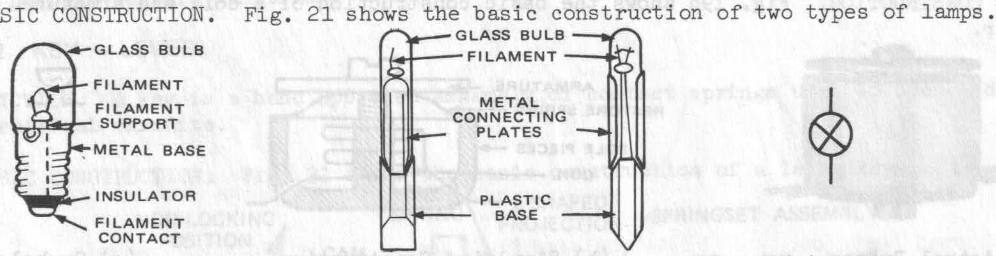
PRINCIPLE OF OPERATION. When a low frequency alternating current is passed through the coil, the reed contacts will make when the current is building up to a maximum value and will break when the current is reducing to zero.

A buzzing noise is produced as a result of the metallic contact between the two reeds.

3.8 LAMPS.

FUNCTION. The purpose of a lamp as an indicating device is to give a visual indication by emitting light, and so attract attention.

BASIC CONSTRUCTION. Fig. 21 shows the basic construction of two types of lamps.



(a) Screw Base. (b) Wedge Base. (c) Symbol.

FIG. 21. TYPICAL LAMPS.

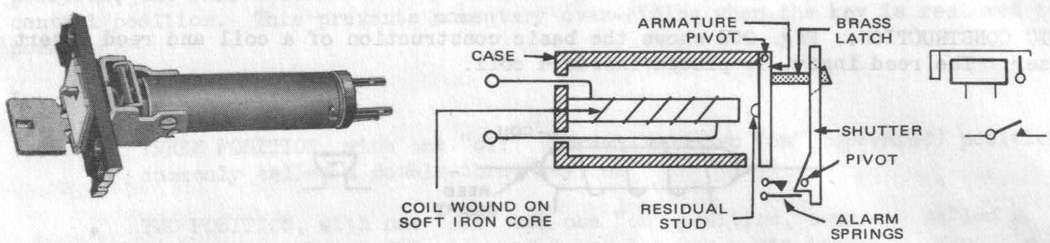
- SCREW BASE LAMP. One end of the filament is terminated on the metal base and the other end to the filament contact on the bottom of the lamp.
- WEDGE BASE LAMP. The ends of the filaments are connected to the metal connecting plates on the side of the lamp.

PRINCIPLE OF OPERATION. When current flows through the thin conducting "filament" enclosed in the evacuated glass bulb, the temperature of the filament is raised to white heat and emits light.

3.9 DROP INDICATOR.

FUNCTION. The function of a drop indicator is to give a visual indication when it is energised. When operated, a shutter drops from a vertical position to display a designation plate.

BASIC CONSTRUCTION. Fig. 22b shows the basic construction of a drop indicator.



(a) Actual Indicator. (b) Simplified Construction. (c) Symbol.

FIG. 22. DROP INDICATOR.

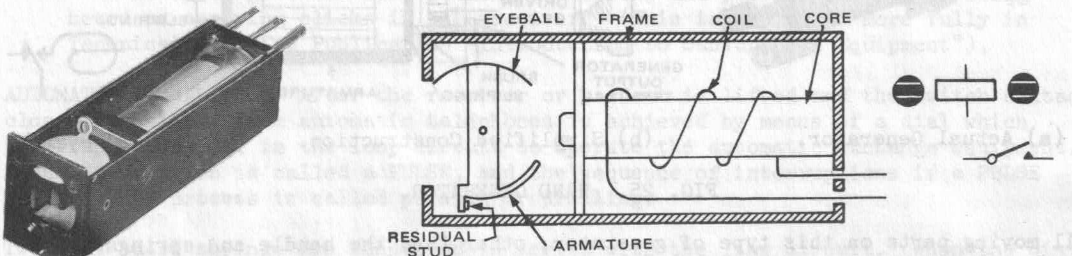
A coil is wound on a soft iron core and enclosed in a soft iron cylindrical case which is open at one end. A soft iron armature is pivoted at the open end. A brass latch is attached to the armature. This latch passes through an opening in a hinged brass shutter, and normally holds the shutter in a vertical position. A non-magnetic residual stud on the armature prevents the armature touching the core during operation. This provides a small gap in the magnetic circuit and prevents the possibility of residual magnetism causing the armature to "stick" in the operated position.

PRINCIPLE OF OPERATION. When alternating ringing current flows through the coil, an alternating magnetic flux is set up in the magnetic circuit consisting of the core, air gap, armature and case. The armature is attracted to the core irrespective of the direction of current, and the latch releases the shutter which drops to disclose the designation plate and give a visual signal to the telephonist. When the shutter drops, it causes a moving spring mounted on the indicator to touch a fixed contact on the mounting plate (alarm springs). This closes the circuit for a trembling bell or buzzer to provide an audible alarm, if required. The shutter is restored manually to its normal position by the telephonist.

3.10 EYEBALL INDICATOR.

FUNCTION. The function of an eyeball indicator is to give a visual indication when it is operated.

BASIC CONSTRUCTION. **Fig.** 23b shows the basic construction of an eyeball indicator.



(a) Actual Indicator. (b) Simplified Construction. (c) Symbol.

FIG. 23. EYEBALL INDICATOR.

A coil is wound on a soft iron core which is attached to a soft iron frame. The ends of the coil connect to tags at the back of the indicator. The moving system consists of a pivoted carriage which has a white or coloured portion of a hollow aluminium sphere (eyeball) on one side and a curved, tongue-shaped, soft-iron armature on the other side.

PRINCIPLE OF OPERATION. When D.C. flows in the coil, the core is magnetised and attracts the armature. The magnetic circuit consists of the core, the soft iron frame, and is completed at the front by the armature and airgap. The armature is attracted to the core and the carriage revolves about its axis so that the "eyeball" is exposed in the aperture in front of the indicator. A small non-magnetic residual stud on the armature prevents the armature "sticking" to the core due to residual magnetism.

As shown in Fig. 24, an extension of the armature (B) touches an insulated contact spring (A) to complete a local alarm circuit, if required. When current ceases, gravity automatically restores the eyeball to normal.

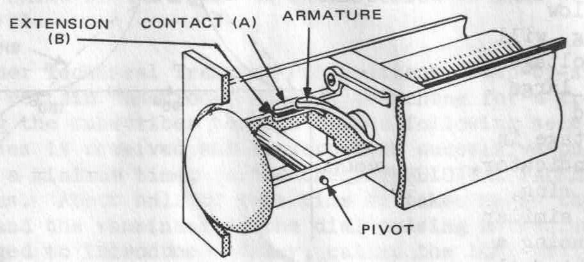
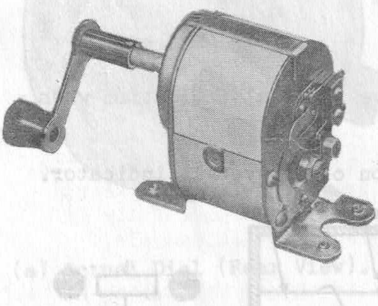


FIG. 24. EYEBALL AND ARMATURE ASSEMBLY OPERATED.

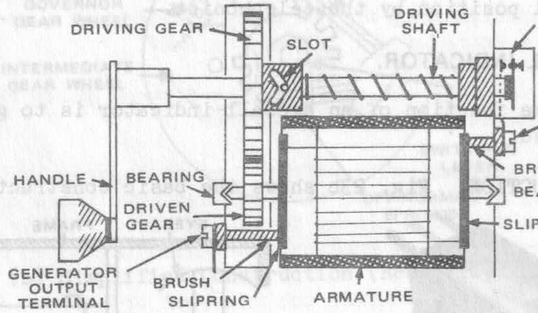
3.11 HAND GENERATORS.

FUNCTION. A hand generator produces an alternating voltage when the handle is turned. This voltage can ring A.C. bells or operate other equipment.

BASIC CONSTRUCTION. Fig. 25b shows the basic construction of a hand generator.



(a) Actual Generator.



(b) Simplified Construction.

(c) Symbol.

FIG. 25. HAND GENERATOR.

All moving parts on this type of generator, other than the handle and springset assembly, are totally enclosed under the permanent magnet (not shown in Fig. 25b). The generator handle is connected to a gear wheel, which in turn drives the armature. The output from the armature is connected via slip rings and brushes to terminals on the outside of the generator. A change-over springset assembly which operates mechanically when the handle is turned, and restores to normal when the handle is released, is fitted at one end of the hand generator. This springset performs switching functions in the signalling circuit.

PRINCIPLE OF OPERATION. Hand generators use the principle of electromagnetic induction. The armature, consisting of many turns of insulated wire wound on a soft iron core, is mechanically rotated in the magnetic field produced by a permanent magnet. As the coil rotates, it cuts the magnetic field and an alternating voltage is induced across the coil. When the coil is connected to a closed circuit, current flows.

The resultant voltage waveform is generally peaked as shown in Fig. 26. This is due to the design of the armature which interacts with the magnetic field in such a way as to alter the output waveshape from that of a sine wave, shown by the broken curve in Fig. 26, to a peaky waveshape.

The hand generator operates indicators and A.C. bells which, at the normal low frequencies of ringing, will respond to the peak voltage applied to them. The large peak voltage of a hand generator is an advantage in that it may drop an indicator, or produce an audible ring, where a generator of similar power output but producing a sine wave voltage might fail to operate the equipment.

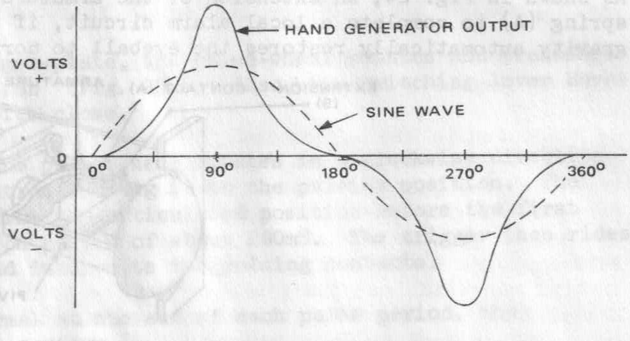


FIG. 26. WAVEFORM OF A HAND GENERATOR.

3.12 DIAL – TRIGGER TYPE.

FUNCTION. A dial generates electrical pulse data which is used by the switching centre equipment to establish the routing of calls.

The functions of a dial are:

- To operate the exchange apparatus by transmitting a number of pulses corresponding to the digit dialled, at a speed of 10 pulses per second and having a ratio of 2 : 1 break to make.
- To provide the minimum time between pulse trains, required by the automatic exchange apparatus.
- To automatically effect circuit changes in the telephone during dialling, so as to give the best pulsing conditions and prevent the pulses being heard as annoying clicks in the receiver. (This is explained more fully in Technical Training Publication "Introduction to Subscribers Equipment").

AUTOMATIC SIGNALLING. After the receiver or handset is lifted and the switch contacts close, signalling from automatic telephones is achieved by means of a dial which interrupts the D.C. in the loop circuit to operate the automatic exchange equipment. Each interruption is called a PULSE, and the sequence of interruptions is a PULSE TRAIN. This process is called pulsing or dialling.

Two dial pulse springs are connected in series with the line circuit. When the dial is operated, contacts on these springs open and close the circuit a number of times corresponding to the digit dialled. Fig. 27 shows graphically how the pulsing contacts operate during a pulse train, the open (break) period being followed by a short closed (make) period.

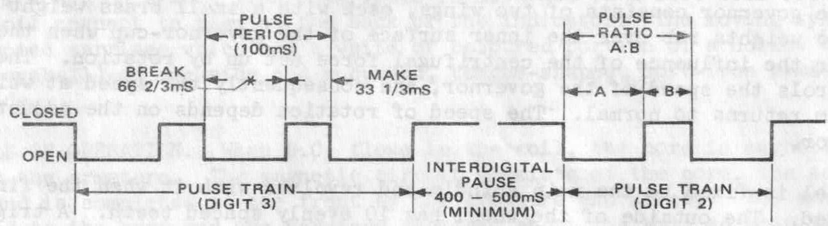


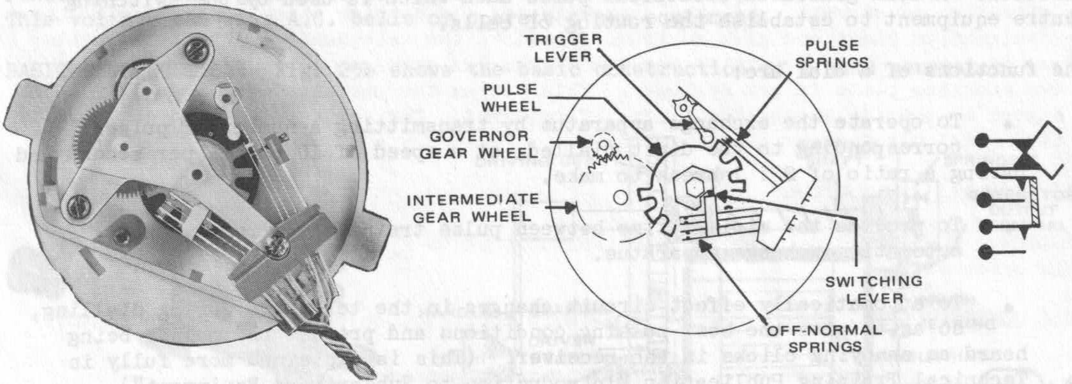
FIG. 27. ILLUSTRATING TERMS USED IN DIALLING.

To ensure satisfactory operation of the exchange equipment, the break period should be $66\frac{2}{3}$ milliseconds (mS), and the make period $33\frac{1}{3}$ mS. The combined break and make period, called the PULSE PERIOD, should be 100mS.

The standard PULSE RATIO is the ratio of break period to make period, that is $66\frac{2}{3}$: $33\frac{1}{3}$, or 2 : 1.

As discussed in other Technical Training Publications, step-by-step automatic exchange equipment performs certain functions, such as searching for a free outlet on a bank level and switching the subscriber through to the following selector, before the first train of pulses is received and between each successive pulse train. These operations require a minimum time, called the INTERDIGITAL PAUSE, of about 400-500mS between pulse trains. About half of this time is taken up by the subscriber in turning the dial, and the remainder by the dial pulsing mechanism which is mechanically arranged to introduce a delay, called the LOST MOTION PERIOD, of about 200mS before each train of pulses.

BASIC CONSTRUCTION OF TRIGGER DIAL. Fig. 28b shows the basic construction of a trigger type dial.



(a) Actual Dial (Rear View). (b) Simplified Construction (Rear View). (c) Symbol.

FIG. 28. TRIGGER DIAL.

The finger-plate (not shown in Fig. 28) is fixed to a main spindle which rotates in the centre of the case. When the spindle is rotated under the control of the finger-plate and then released, a spring returns it to the rest position. The spring (not shown in Fig. 28) which is similar to the main spring in a watch, is assembled in a case, and mounted at the back of the dial. A stop post or screw keeps the spring in a partially wound condition and also limits the rotation of the finger-plate and dial mechanism. The main gear wheel (not shown in Fig. 28) is fixed to the main spindle behind the finger-plate, and drives the governor gear mechanism, via an intermediate gear, which controls the pulse speed when the finger-plate is returning to the rest position. The governor consists of two wings, each with a small brass weight at the free end. The weights rub over the inner surface of the governor-cup when they move outwards under the influence of the centrifugal force set up by rotation. The friction controls the speed of the governor, and consequently the speed at which the dial mechanism returns to normal. The speed of rotation depends on the adjustment of the governor.

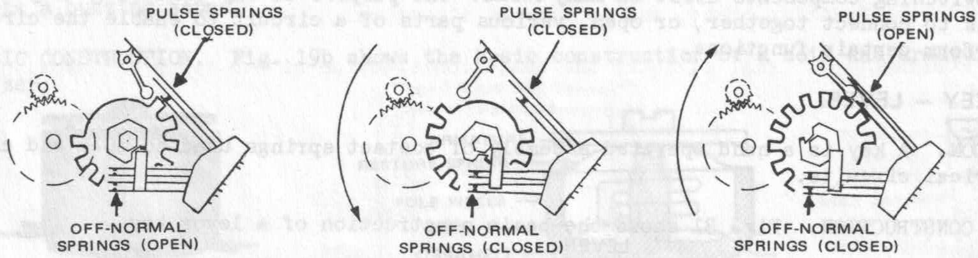
The pulse-wheel is fixed to the main spindle and revolves with it when the finger-plate is turned. The outside of the wheel has 10 evenly spaced teeth. A trigger lever is pivotted at one end of a pin which is fixed to the case. A flat spring rests against the pivotted end. At the other end of the trigger is an extension lug, which rides over the teeth of the pulse-wheel.

PRINCIPLE OF OPERATION. In the normal position (Fig. 29a), the trigger lies underneath the pulse springs.

During the forward motion of the finger-plate, the pulse-wheel rotates and transfers the trigger to the articulated position (Fig. 29b). Also, the switching lever moves away from the off-normal springs, which close.

When the finger-plate is released, the pulse-wheel rotates in a clockwise direction (Fig. 29c) and picks up the trigger transferring it to the pulsing position. The time taken for the trigger to move from the articulated position before the first pulse is given, provides a lost-motion period of about 200mS. The trigger then rides over the teeth of the pulse-wheel and interrupts the pulsing contacts.

When the finger-plate returns to normal at the end of each pulse period, the switching lever opens the off-normal springs.



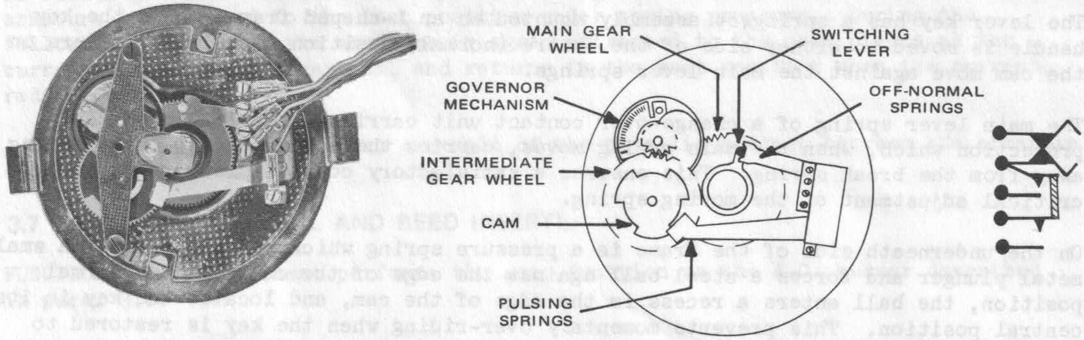
(a) Normal Position. (b) Articulated Position. (c) Pulsing Position.

FIG. 29. ACTION OF THE PULSING MECHANISM OF A TRIGGER DIAL.

3.13 DIAL – REVOLVING CAM TYPE.

FUNCTION. The revolving cam type dial performs the same function as the trigger type dial described in para. 3.12.

BASIC CONSTRUCTION. Fig. 30b shows the basic construction of a revolving cam type dial.



(a) Actual Dial (Rear View). (b) Simplified Construction (Rear View). (c) Symbol.

FIG. 30. REVOLVING CAM DIAL.

The finger-plate (not shown in Fig. 30) is fixed to a main spindle. The main spring is inside the main spindle. Attached to the main spindle is the main gear-wheel and switching lever which revolve when the finger-plate is turned. The gearing is such that the main gear-wheel turns an intermediate gear-wheel underneath the revolving cam. Detent springs prevent the cam from moving during the windup of the dial. When the finger-plate is released, the cam, with three evenly spaced teeth, moves through the pulsing springs. The springset assembly consists of pulsing springs (normally closed) and off-normal springs (normally open). The speed of rotation depends on the governor adjustment.

PRINCIPLE OF OPERATION. In the normal position the cam teeth do not interrupt the pulse spring contacts.

During the forward motion of the finger-plate, the cam does not rotate, but the switching lever moves and the off-normal springs operate. When the finger-plate is released, the cam rotates and interrupts the pulsing contacts.

4. SWITCHING COMPONENTS

4.1 Switching components exist in many forms. The purpose of any switching component is to connect together, or open, various parts of a circuit to enable the circuit to perform certain functions.

4.2 KEY – LEVER.

FUNCTION. A key is a hand operated assembly of contact springs used to open and close electrical circuits.

BASIC CONSTRUCTION. Fig. 31 shows the basic construction of a lever key.

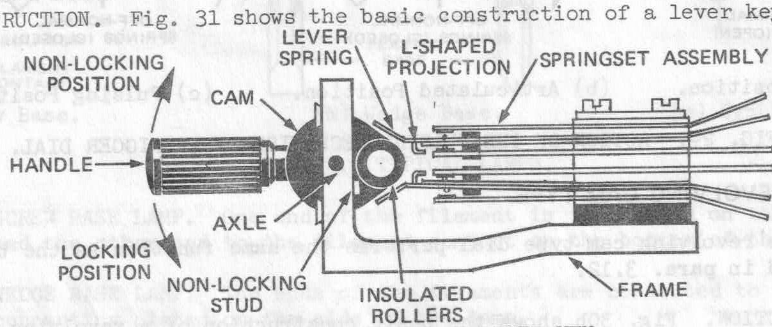


FIG. 31. OLDER STYLE LEVER KEY.

The lever key has a springset assembly mounted on an L-shaped frame. When the key handle is moved to either side of the centre (normal) position, insulated rollers on the cam move against the main lever springs.

The main lever spring of a change-over contact unit carries a small L-shaped projection which, when the main spring moves, carries the corresponding short spring away from the break spring. This ensures a satisfactory contact pressure without critical adjustment of the moving spring.

On the underneath side of the frame is a pressure spring which presses against a small metal plunger and forces a steel ball against the edge of the cam. In the normal position, the ball enters a recess in the edge of the cam, and locates the key in its central position. This prevents momentary over-riding when the key is restored to normal.

Lever keys are either:-

- THREE POSITION, with one "off" (normal) and two "on" (operated) positions, commonly called a double-throw key, or
- TWO POSITION, with one "off" and one "on" position, commonly called a single-throw key. This type of lever key has a pin inserted through a hole in the cam to prevent movement into the unused position.

The operated positions are either:-

- LOCKING, which means they remain operated without being held, or
- NON-LOCKING, which means they restore to the normal position due to spring tension when released by the hand. This type of lever key has studs on the frame, which limit the travel of the rollers, and prevent locking. Also the ends of the main lever spring are set at a sharper angle.

Some three-position keys have a combination of one locking and one non-locking operated positions. (Fig. 31 illustrates this combination).

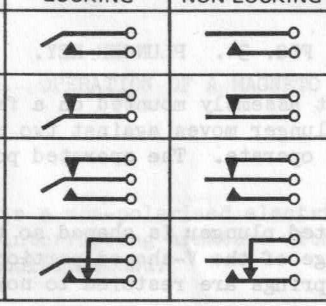
CONTACT UNITS. A contact unit is a combination of a lever spring and the springs electrically associated with it.

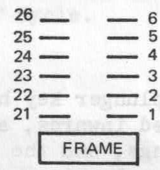
In any contact unit

- the LEVER spring is the spring by which the unit is operated.
- the MAKE spring makes connection with the lever spring when operated.
- the BREAK spring breaks connection with the lever spring when operated.

Keys are made up of various contact units, as required (Fig. 32). Note that the terms "make" and "break" refer to the operated condition of the contacts, and not to the unoperated condition. The difference between the change-over and the make-before-break is that, in the latter, the "make" contacts close before the "break" contacts open.

CONTACT UNIT	DRAWING SYMBOL LOCKING	DRAWING SYMBOL NON-LOCKING	LETTER SYMBOL
MAKE			M
BREAK			B
CHANGE-OVER			C
MAKE-BEFORE-BREAK CHANGE-OVER			K





SPRING NUMBERING (VIEWED FROM TAG END)

FIG. 32. LEVER KEY CONTACT UNITS.

A newer design lever key (Fig. 33) is available and has the following improvements over the older style lever key:-

- The key occupies a smaller space.
- The key handle is of a modern shape.
- A light pressed-steel frame is used instead of a heavy cast frame.
- Twin contacts are provided on the springs.
- The lever springs are operated by a comb-shaped plate operated by the key handle.
- The fixing screws for the key are provided at the rear of the key. They are not visible as were the older style.

This key can be provided with one of the five different mechanical actions available with the older style lever key.

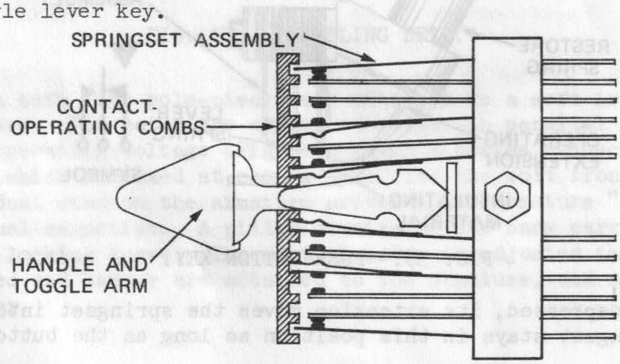


FIG. 33. MODERN STYLE LEVER KEY.

4.3 KEY – PLUNGER.

FUNCTION. The plunger key has the same function as the lever key described in para. 4.2.

BASIC CONSTRUCTION. Fig. 34 shows the basic construction of a plunger key.

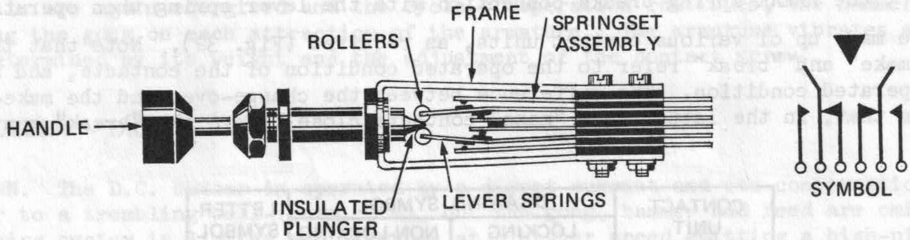


FIG. 34. PLUNGER KEY.

The plunger key has a springset assembly mounted on a frame. When the key handle is pushed inwards, an insulated plunger moves against two rollers at the ends of the lever springs, and the contact units operate. The operated position may be either locking or non-locking.

In the locking key, the insulated plunger is shaped so that when the lever spring rollers ride over the upper edge of the V-shaped portion, the return of the plunger to normal is prevented. The springs are restored to normal by pulling the key handle outwards.

In the non-locking key, the V-shaped portion of the plunger is longer, so that the lever spring rollers do not ride over the upper edge, and when released, the springs and plunger restore to normal due to spring tension.

CONTACT UNITS. As with lever keys, the contact units may be M, B, C or K.

4.4 KEY – PUSH.

FUNCTION. The push key has the same function as the lever key described in para. 4.2.

BASIC CONSTRUCTION. Fig. 35 shows the basic construction of a push key.

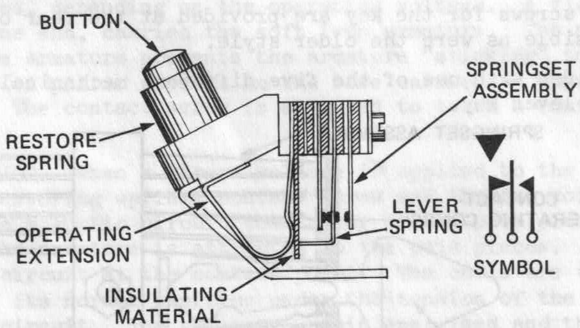


FIG. 35. PUSH BUTTON KEY.

When the button is depressed, its extension moves the springset into the operated position. The springset stays in this position as long as the button is depressed (non-locking).

4.5 KEY – ILLUMINATED PUSH.

FUNCTION. The illuminated push key has the same function as the lever key described in para. 4.2, but with the additional facility of lighting a lamp inside the barrel of the key to give a visual indication when the key is operated.

BASIC CONSTRUCTION. Fig. 36 shows the basic construction of an illuminated push key.

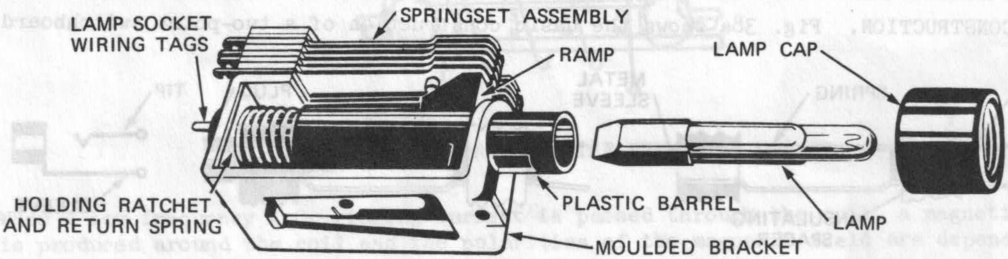


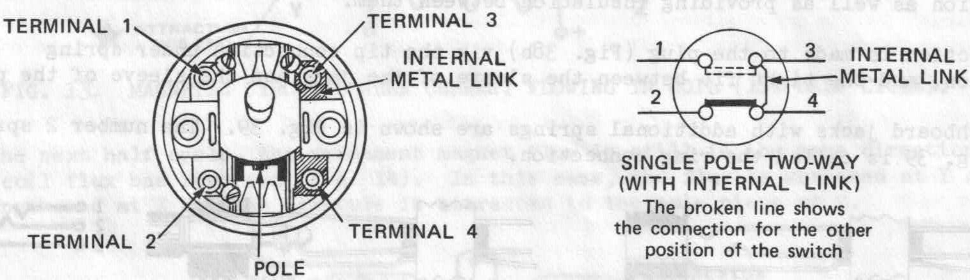
FIG. 36. ILLUMINATED PUSH KEY.

A plastic barrel passes through the moulded bracket and is attached to the rear end of the frame by a holding ratchet and return spring. A ramp, attached to the barrel, operates the springsets when the barrel is depressed into the down position. A lamp may be fitted into a lamp socket fitted in the barrel and wired into a circuit from the two tags that extend from the base of the key. A lamp cap fits over the top of the barrel. The contact units are miniature relay springsets.

4.6 TUMBLER SWITCH.

FUNCTION. A tumbler switch is a hand operated switch used to open and close electrical circuits.

BASIC CONSTRUCTION. Fig. 37 shows the basic construction of a tumbler switch.



(a) Simplified Construction. (b) Symbol.

FIG. 37. TUMBLER SWITCH.

Within the bakelite moulding are four terminals (to which the circuit wiring is connected), each with a metal extension piece under spring tension. Attached to the switch operating lever (tumbler) is a short length of metal, called a pole. The purpose of this pole is to make an electrical connection between two terminals via their extension pieces. In Fig. 37 the connection is shown between terminals 2 and 4.

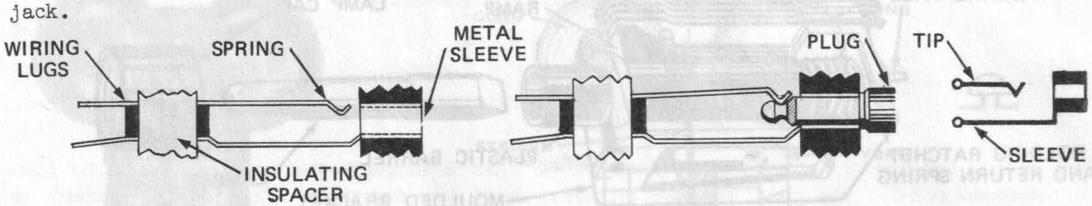
When the switch operating lever (tumbler) is operated to the other position, an electrical connection is made between the other two terminals. In Fig. 37b this connection is shown as the broken line between terminals 1 and 3.

A metal link is placed between terminals 3 and 4 of the switch to maintain an electrical connection when this switch is required to perform certain electrical functions (not described in this Technical Training Publication).

4.7 JACKS – SWITCHBOARD.

FUNCTION. A switchboard jack enables external connection to certain points of circuits by inserting a switchboard plug (para. 4.8) with a cord attached (para. 4.9). Switchboard jacks are constructed in various physical sizes and with varying number of springs.

BASIC CONSTRUCTION. Fig. 38a shows the basic construction of a two-point switchboard jack.



(a) Simplified Construction. (b) Jack With Plug Inserted. (c) Symbol.

FIG. 38. TWO-POINT SWITCHBOARD JACK.

Wiring is extended from the required point of a circuit and connected to the two wiring lugs at the rear of the switchboard jack. The wiring lugs are extensions of:-

- a metal connecting piece (under spring tension to ensure a good contact with the plug, when inserted) called the tip connection, and
- a block of metal with a hole machined through it, called the sleeve connection.

Separating these two lugs is an insulating material which holds the lugs firmly in position as well as providing insulation between them.

Connection is made to the plug (Fig. 38b) via the tip connection under spring tension, and the tight fit between the sleeve of the jack and the sleeve of the plug.

Switchboard jacks with additional springs are shown in Fig. 39. The number 2 spring in Fig. 39 is called the ring connection.

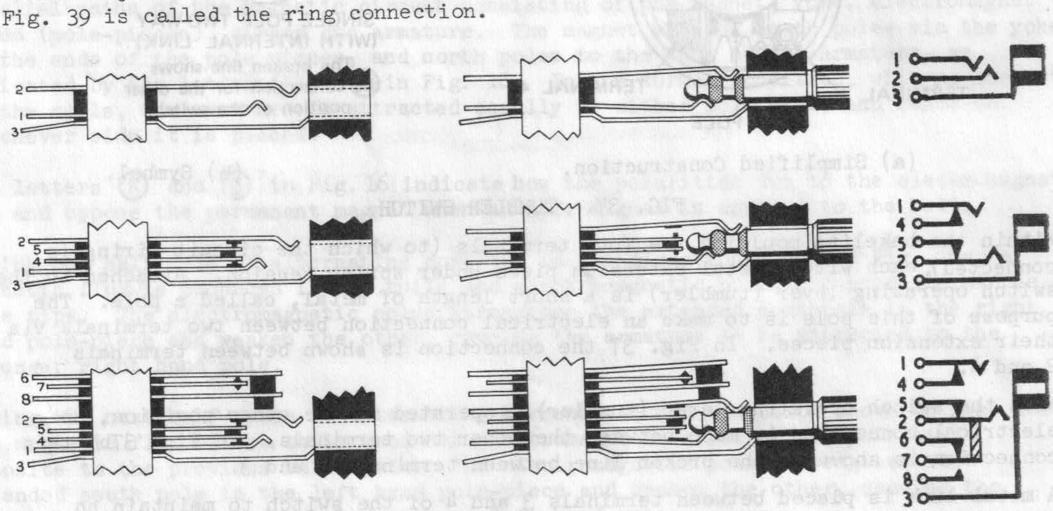
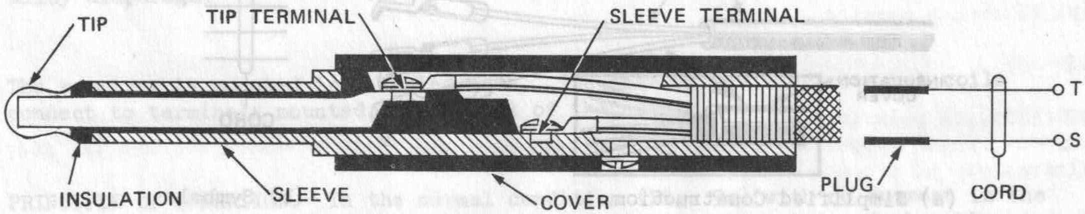


FIG. 39. TYPICAL THREE, FIVE AND EIGHT-POINT SWITCHBOARD JACKS.

4.8 PLUGS – SWITCHBOARD.

FUNCTION. A switchboard plug is a device which makes connection to a switchboard jack (para. 4.7) and extends the circuit from the jack to other equipment via a cord (para 4.9).

BASIC CONSTRUCTION. Fig. 40 shows the basic construction of a two-conductor switchboard plug.



(a) Simplified Construction. (b) Symbol.

FIG. 40. TWO-CONDUCTOR SWITCHBOARD PLUG.

Switchboard plugs are constructed in various physical sizes and with a varying number of connections per plug.

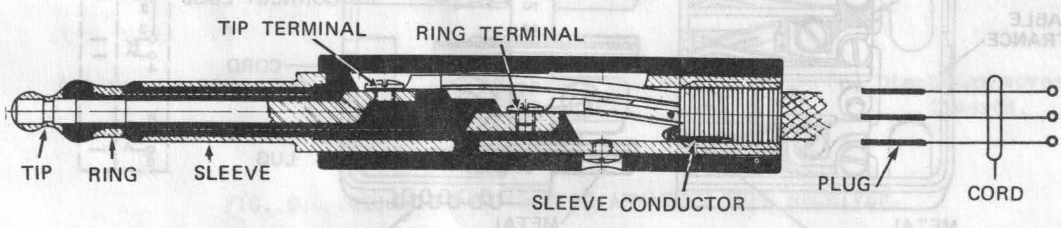
The metal tip connection is so shaped to enable the tip spring of the switchboard jack to ride over the leading edge of the plug and latch into the grooved section. This tip connection is reduced in diameter after the grooved section and remains so until it enters the cord connection area, (under the cover) where it is flattened out, drilled and tapped to take a small gauge screw to which a conductor of a cord is terminated.

The metal sleeve connection is straight and is designed to make a tight fit with the sleeve of the switchboard jack. This sleeve connection is hollow and extends from just behind the grooved section of the tip into the cord connection area, where the metal section is reduced from a cylinder into a narrow section to which a small gauge screw is attached to terminate the other conductor of the cord.

An insulating material separates the tip and sleeve connections, at all points where the two are in close proximity to each other.

An insulating cover is placed around the cord connection area to prevent people from receiving electric shocks from exposed terminals.

A three-conductor switchboard plug is shown in Fig. 41.



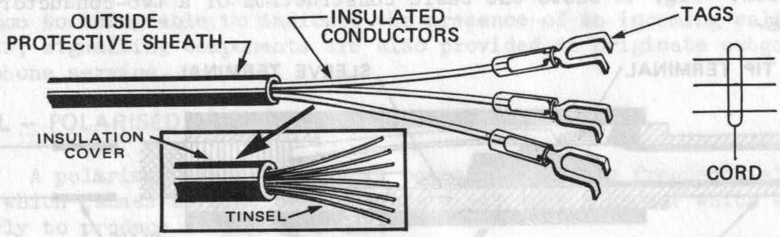
(a) Simplified Construction. (b) Symbol.

FIG. 41. THREE-CONDUCTOR SWITCHBOARD PLUG.

4.9 CORDS.

FUNCTION. A cord is a flexible combination of two or more insulated covered conductors grouped together to extend the connection from one item of equipment to another.

BASIC CONSTRUCTION. Fig. 42 shows the basic construction of a three-conductor cord.



(a) Simplified Construction. (b) Symbol.

FIG. 42. THREE-CONDUCTOR CORD.

Cords are manufactured in various lengths, numbers of conductors, diameters of conductors, types of conductors, types of insulation and types of covering.

In a typical three-conductor cord, each conductor consists of a number of thin copper alloy wires (called tinsel threads) wound around cotton threads, with an insulation covering of cotton braid, rubber or P.V.C. These are spiralled together and made up to a circular cross-section.

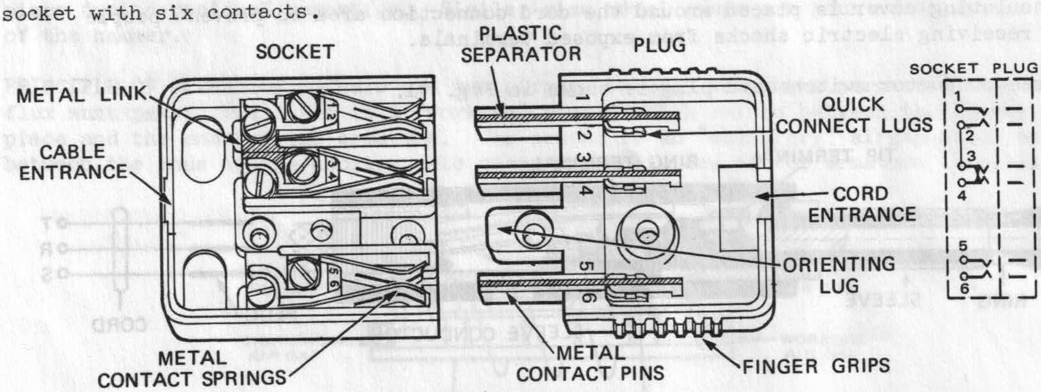
To hold the conductors together and provide some measure of protection, a sheath is placed around the insulated conductors. To identify each conductor, a different coloured (or combination of colours) marking is used on the insulation.

Tags are crimped onto the conductors to enable them to be terminated on equipment. It is not practicable to solder the tinsel wires to the tags because the cotton threads would char under the heat of a soldering iron.

4.10 TELEPHONE PLUG AND SOCKET

FUNCTION. These items are used to establish a connection between the end of the telephone service cabling and the telephone instrument. The telephone service cabling is terminated on the terminals in the socket. To the plug is terminated a cord which has its other end terminated in the telephone instrument. When the plug and socket are mated, a connection is established between the telephone service cabling and the instrument.

BASIC CONSTRUCTION. Fig. 43 shows the basic construction of a flat telephone plug and socket with six contacts.



(a) Simplified Construction. (b) Symbol.

FIG. 43. TELEPHONE PLUG AND SOCKET.

THE PLUG is constructed of a plastic moulding, and consists of a case (Fig. 43) and a cover (not shown). The case if fitted with six metal contact pins formed into three contact pin pairs projecting from the plug. Each pin has a number moulded adjacent to it on the case. The pins of a pair are insulated from each other by a plastic separator inserted between them. Each pin and separator group is held firmly in a slot in the plug case, but can be removed and easily re-inserted to facilitate fitting of the cord conductor tags; the pins are locked in position when the cover is replaced. The heel ends of the pins (inside the plug) are formed into lugs to take the tags of the cord conductors, the plastic separators extending sufficiently far to insulate the cord tags from each other. Provision is made for a cord grommet entrance in the case and securing of the grommet by the cover. The bottoms of the leading edges of the pins are radiused to allow an angled approach of the plug to the socket. A moulded projection tongue between the pins acts as a locating device to give correct orientation of the plug and socket during insertion of the plug. A captive screw secures the cover to the case.

THE SOCKET is constructed of a plastic moulding, and consists of a case (Fig. 43) and a cover (not shown). It is fitted with six metal contact springs formed into three pairs to mate-up with the plug. At the end of each spring is a washer and screw, to which the telephone service cabling is terminated. A metal link is supplied between terminals 2 and 3. Each spring has a number moulded adjacent to it on the case. Contact springs 1 and 2 (also 5 and 6) are separated by moulded projections on the inside of the case. Contact springs 3 and 4 are not held apart by any projection and under spring tension establish a connection between terminals 3 and 4 of the socket. A captive screw secures the cover to the case.

4.11 GRAVITY SWITCH.

FUNCTION. A gravity switch is a mechanically operated springset actuated by lifting a handset off a telephone. When the handset is lifted, the contacts of the springset bring about different circuit conditions and so allow the telephone to perform functions that could not be performed when the handset is replaced.

BASIC CONSTRUCTION. **Fig. 44 shows the basic construction of a typical gravity switch.**

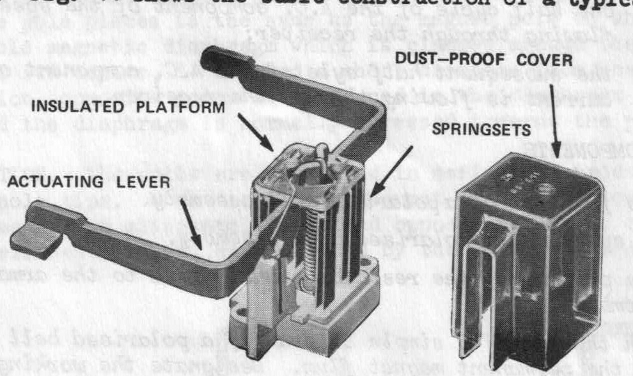


FIG. 44. GRAVITY SWITCH.

To the base of the gravity switch is attached the springsets and two pillars on which the actuating lever is pivotted. On the top of the lever springs is fitted an insulated platform which is also attached to the actuating lever. When the actuating lever moves from one position to the other, the lever springs also move to effect the other electrical condition of the springsets.

When the handset is replaced on the telephone instrument, the weight of the handset holds the actuating lever and the springsets in one condition. When the handset is lifted, a spring attached between the actuating lever and the base "toggles", and holds the lever and springsets in the other condition. Extension lugs on the two pillars prevents the springsets from having too much travel. A dust-proof cover is placed over the springsets to reduce spring-contact troubles due to dust.

5. TEST QUESTIONS

TRANSMITTING AND RECEIVING COMPONENTS.

1. *State the function of a carbon type transmitter.*
2. *Draw the symbol of a carbon type transmitter.*
3. *What determines the resistance of a carbon type transmitter?*
4. *With the aid of a simple diagram, explain the operation of a carbon type transmitter when a sound wave compression strikes the diaphragm.*
5. *With the aid of a simple diagram, explain the operation of a carbon type transmitter when a sound wave rarefaction strikes the diaphragm.*
6. *State the function of a telephone receiver.*
7. *Draw the symbol of a telephone receiver.*
8. *Draw 3 simple diagrams of a magnetic diaphragm type receiver showing magnetic polarities of the pole pieces and diaphragm, and the relative position of the diaphragm to the pole pieces when:*
    - *no current is flowing through the receiver;*
    - *one half cycle of the A.C. component of the speech current is flowing through the receiver;*
    - *the subsequent half cycle of the A.C. component of the speech current is flowing through the receiver.*
9. *Draw 3 simple diagrams of a non-magnetic diaphragm type receiver showing magnetic polarities of the pole pieces and armature, and the relative position of the diaphragm when:*
    - *no current is flowing through the receiver;*
    - *one half cycle of the A.C. component of the speech current is flowing through the receiver;*
    - *the subsequent half cyle of the A.C. component of the speech current is flowing through the receiver.*

SIGNALLING COMPONENTS.

10. *State the function of a polarised bell assembly.*
11. *Draw the symbol of a polarised bell assembly.*
12. *State the purpose of the residual studs fitted to the armature of a polaried bell assembly.*
13. *Show with the aid of a simple diagram of a polarised bell assembly, the paths of the permanent magnet flux. Designate the working and auxiliary airgaps.*
14. *Does the magnetic flux, which is produced by the low frequency A.C. ringing current flowing in the coil of a polarised bell assembly pass through.*
    - *the auxiliary airgap?*
    - *the working airgap?*
15. *Briefly explain how the permanent magnet flux and the electromagnet flux interact during each half cycle of ringing current to cause the polarised bell assembly to operate.*

16. *Draw 2 simple diagrams of a magneto bell, showing magnetic polarities of the pole pieces, coils and armature, and the position of the armature in relation to the pole pieces during two separate half cycles of alternating ringing current.*

17. *State the function of a trembling bell.*

18. *Draw the symbol of a trembling bell.*

19. *Briefly explain the operation of a trembling bell when a direct voltage is applied to the terminals.*

20. *State the function of a D.C. buzzer.*

21. *Draw the symbol of a D.C. buzzer.*

22. *State the function of an A.C. buzzer.*

23. *Draw the symbol of an A.C. buzzer.*

24. *Describe briefly the operation of the coil and armature type A.C. buzzer when ringing current is applied to the coil.*

25. *Describe briefly the operation of the coil and reed insert type A.C. buzzer when ringing current is applied to the coil.*

26. *State the function of a lamp.*

27. *Draw the symbol of a lamp.*

28. *Describe the principle of operation of a lamp.*

29. *State the function of a drop indicator.*

30. *Draw the symbol of a drop indicator.*

31. *Describe the principle of operation of a drop indicator.*

32. *State the function of an eyeball indicator.*

33. *Draw the symbol of an eyeball indicator.*

34. *Describe the principle of operation of an eyeball indicator.*

35. *State the function of a hand generator.*

36. *Draw the symbol of a hand generator.*

37. *State the principle of operation of a hand generator.*

38. *Draw a typical output voltage waveform of a hand generator.*

39. *State the functions of a telephone dial.*

40. *Draw the symbol of a telephone dial.*

41. *Explain the following dial terms:*
    - *Pulse;*
    - *Pulse train;*
    - *Break period;*
    - *Make period;*
    - *Pulse period;*
    - *Pulse ratio;*
    - *Interdigital pause;*
    - *Lost motion period.*

SWITCHING COMPONENTS.

42. *State the function of a lever key.*
43. *Explain the following lever key terms:*
    - *Locking;*
    - *Non-locking;*
    - *Three position;*
    - *Two position;*
    - *Contact unit;*
    - *Lever spring;*
    - *Make spring;*
    - *Break spring.*
44. *State the function of a tumbler switch.*
45. *Draw the symbol of a single-pole two-way tumbler switch.*
46. *State the purpose of the pole in a tumbler switch.*
47. *State the function of a switchboard jack.*
48. *Draw the symbols of the following switchboard jacks:*
    - *Two point;*
    - *Three point;*
    - *Five point;*
    - *Eight point.*
49. *Describe briefly the construction of a two point switchboard jack.*
50. *State the function of a switchboard plug.*
51. *State the function of a cord.*
52. *Draw the symbol of a three-conductor cord connected to a three-conductor switchboard plug.*
53. *State the function of a telephone plug and socket.*
54. *Draw the symbol of a telephone plug and socket.*
55. *State the function of a gravity switch.*

END OF PAPER